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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/049,971	02/12/2002	Satoshi Komiya	86396	8978

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Welsh & Katz
120 South Riverside Plaza
22nd Floor
Chicago, IL 60606

EXAMINER	
SONG, MATTHEW J	
ART UNIT	PAPER NUMBER
1765	5

DATE MAILED: 02/05/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)
	10/049,971	KOMIYA ET AL.
	Examiner	Art Unit
	Matthew J Song	1765

-- The MAILING DATE of this communication appears on the c ver sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____ .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-9* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-9* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Pri rity under 35 U.S.C. §§ 119 and 120

13)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☒ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) *4* .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Claim Objections

1. Claims 2-3 are objected to because of the following informalities: Claim 2 recites, "LPDs" in line 3, the examiner suggests replacing or preceding "LPDs" with "Light Point Defects". Appropriate correction is required.

2. Claim 5 is objected to because of the following informalities: Claim 5 recites, "lowered corresponding to an in accordance with increase in nitrogen" in line 3. The grammar is this claim is flawed. The examiner suggests placing "an" prior the word increase and changing "corresping to **an** in accordance" to "corresponding to **and** in accordance". Appropriate correction is required.

Claim Rejections - 35 USC § 112

3. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

4. Claim 1 is rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claim 1 recites "a hill-shaped defect" in line 2. "A hill shaped defect" is indefinite because a hill shape can be interpreted to take on many varying shapes.

Claim Rejections - 35 USC § 102

5. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

6. Claim 1 is rejected under 35 U.S.C. 102(e) as being anticipated by Asayama et al (US 2002/0142171).

Asayama et al discloses a single crystal silicon wafer doped with nitrogen at a concentration of 10^{14} atoms/cm3 and a 5 micrometer thick epitaxial layer formed at a temperature of 1150°C. Asayama et al also discloses defect densities on the surface of the epitaxial layer were determined under an optical microscope and defects were not observed on the surface of the epitaxial layer ([0055]-[0056]).

Asayama et al is silent to a hill shaped defect is not observed. However, Asayama et al discloses defects in general are not observed on the epitaxial layer, which inherently encompasses hill shaped defects.

Claim Rejections - 35 USC § 103

7. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

8. Claims 1-3 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wijarankula (US 5,961,713) in view of Graef et al (US 5,935,320) or Tamatsuka et al (US 6,162,708).

Wijarankula discloses a silicon substrate **12** with a diameter of approximately 200 mm and includes a boron dopant of $3x10^{18}$ atoms/cm3 and approximately 23 ppma oxygen. Wijarankula also discloses using semiconductor silicon substrates and epitaxial layers having wide ranges of thicknesses, dopants and dopant concentrations (col 4, ln 10-43). Wijarnakula also discloses a typical microdefect **14** with a diameter greater than 0.1 micrometer (100 nm), this reads on applicant's LPDs and hill defect, and growing a single crystal by the Czochralski method and slicing an ingot into semiconductor silicon wafers (col 4, ln 44-67). Wijarankula also discloses a process step **46** for depositing an epitaxial layer, where the epitaxial layer forms a microdefect-free layer **16** and the concentration of microdefects **14** decreases over a finite transition region **30** from a relatively high concentration in the substrate bulk to approximately zero (col 5, ln 1-67, col 6, ln 1-40 and Figs 2-3).

Wijranakula does not discloses a substrate doped with nitrogen.

In a process for forming silicon semiconductor wafers, note entire reference, Graef et al teaches preparing a silicon single crystal having an oxygen concentration of at least $4x10^{17}/cm^3$ and a nitrogen doping concentration of at least $1x10^{14}/cm^3$ and processing the silicon single crystal to form silicon wafers with a low defect density (col 2, ln 40-67). Graef et al also teaches the proportion of large defects decreases greatly with the increase in the degree of nitrogen

doping (col 6, ln 10-20 and Example 2). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Wijarnakula with Graef et al's nitrogen doped silicon substrate to reduce larger defects in the silicon substrate wafer.

In a process for forming an epitaxial silicon wafer, note entire reference, Tamatsuka et al teaches an epitaxial silicon single wafer characterized in that a silicon single crystal ingot which nitrogen is doped is grown by the Czochralski method and the resultant silicon single crystal ingot is sliced to produce a silicon single crystal wafer and then a epitaxial layer is formed in the surface layer portion of the resultant silicon single crystal wafer (col 2, ln 1-15). Tamatsuka et al also teaches when the nitrogen concentration of the silicon single crystal wafer is $1x10^{13}$ to $1x10^{14}$ atoms/cm3, it is possible to decrease the defect density on the surface of the epitaxial layer (col 4, ln 1-67). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Wijarankula with Tamatsuka's nitrogen doped silicon wafer to decrease the defect density on the surface of an epitaxial layer.

Referring to claim 1, Wijarankula teaches a microdefect free epitaxial layer, this reads on a hill shaped defect is not observed on the epitaxial film because a hill shaped defect has a height of about 10 nm and a width of about 10 micrometers, as defined in the instant specification on page 5, which is clearly larger than the 0.1 micrometer microdefect taught by Wijarakula.

Referring to claim 2-3, Wijrankula teaches a microdefect size of greater than 0.1 micrometer (100 nm) or greater with a density of approximately zero for a 200 mm wafer. Overlapping ranges are held to be obvious (MPEP 2144.05).

9. Claims 4-9 are rejected under 35 U.S.C. 103(a) as being unpatentable over Graef et al (US 5,935,320).

Graef et al teaches preparing a silicon single crystal having an oxygen concentration of at least $4x10^{17}/cm^3$ and a nitrogen doping concentration of at least $1x10^{14}/cm^3$ and processing the silicon single crystal to form silicon wafers with a low defect density (col 2, ln 1-67). Graef et al also teaches the proportion of large defects decreases greatly with the increase in the degree of nitrogen doping (col 6, ln 10-20 and Example 2). Graef et al also teaches test have shown that the effect of doping the single crystal with nitrogen in terms of the defect size distribution must also be considered in connection with the doping of the single crystal with oxygen and for the same nitrogen doping, the proportion of small defects increases as the oxygen doping decreases (col 3, ln 15-45). Graef et al also teaches the single crystal is produced by the Czochralski method (col 3, ln 45-67).

Graef et al does not teach the nitrogen concentration is about $3x10^{15}$ when the oxygen concentration is $7x10^{17}$ atoms/cm3 and nitrogen concentration is about $3x10^{14}$ atoms/cm3 when the oxygen concentration is $1.6x10^{18}$ atoms/cm3.

It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Graef et al by optimizing the nitrogen and oxygen concentration by conducting routine experimentation of result effective variables to minimize large defects. Furthermore, the selection of reaction parameters such as temperature and concentration is obvious (In re Aller 105 USPQ 233, 255 (CCPA 1955)).

Referring to claim 5 and 9, Graef et al does not teach the oxygen concentration is lowered corresponding to and in accordance with an increase in nitrogen concentration. Graef et al

teaches doping the single crystal with nitrogen in terms of the defect size distribution must also be considered in connection with the doping of the single crystal with oxygen and for the same nitrogen doping. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Graef et al by optimizing the oxygen concentration to the nitrogen concentration by conducting routine experimentation of result effective variables because a connection with the oxygen concentration to the nitrogen concentration is known.

Referring to claims 6-7, Graef et al does not teach the claimed concentrations of nitrogen and oxygen. However, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Graef et al by optimizing the nitrogen and oxygen concentration by conducting routine experimentation of result effective variables to minimize large defects. Furthermore, the selection of reaction parameters such as temperature and concentration is obvious (In re Aller 105 USPQ 233, 255 (CCPA 1955)).

Referring to claim 8, Graef et al teaches a silicon ingot with a nitrogen doping concentration of at least $1x10^{14}/cm^3$. Overlapping ranges are held to be obvious (MPEP 2144.05).

10. Claims 4-9 are rejected under 35 U.S.C. 103(a) as being unpatentable over Tamatsuka et al (US 6,162,708).

Tamatsuka et al teaches an epitaxial silicon single wafer characterized in that a silicon single crystal ingot which nitrogen is doped to a concentration of $1x10^{10}$ to $5x10^{15}$ atoms/cm^3 is grown by the Czochralski method and the resultant silicon single crystal ingot is sliced to

produce a silicon single crystal wafer (col 2, ln 1-67). Tamatsuka et al also teaches the oxygen concentration is 18 ppma ($9x10^{17}$ atoms/cm3) or less (col 4, ln 1-25).

Tamatsuka et al does not teach the claimed nitrogen and oxygen concentrations. However, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Tamatsuka et al by optimizing the nitrogen and oxygen concentration by conducting routine experimentation of result effective variables to minimize large defects. Furthermore, the selection of reaction parameters such as temperature and concentration is obvious (In re Aller 105 USPQ 233, 255 (CCPA 1955)).

Referring to claims 5 and 9, Tamatsuka et al does not teach the oxygen concentration is lowered corresponding to and in accordance with an increase in nitrogen concentration. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Tamatsuka et al by optimizing the oxygen concentration to the nitrogen concentration by conducting routine experimentation of result effective variables because a connection with the oxygen concentration to the nitrogen concentration is known

Conclusion

11. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Krishna et al (US 5,571,373) teaches polishing a semiconductor wafer to reduce LPDs to about 7 per wafer (col 7, ln 30-67).

Kobayashi et al (US 6,245,311) teaches a heat treatment to obtain a silicon wafer having the number of LPDs not less than 0.12 micrometers of 20 COPs/8 inch wafer (col 11, ln 1-50).

Wilson et al (US 6,284,384) teaches a correlation between atoms/cm3 of oxygen to ppm, where $9x10^{17}$ atoms/cm3 is equivalent to 18 ppm (col 8, ln 60-67 and col 9, ln 1-15) and a wafer with defects of 0.12 micrometers is less than $0.5/cm^2$ (col 16).

12. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Matthew J Song whose telephone number is 703-305-4953. The examiner can normally be reached on M-F 9:00-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Benjamin L Utech can be reached on 703-308-3868. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9310 for regular communications and 703-872-9311 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0661.

Matthew J Song
Examiner
Art Unit 1765

MJS
January 28, 2003

BENJAMIN L. UTECH
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 1700